SLUSH FLOWS ON HIGHWAY RV80 TO THE CITY OF BODOE, NORTHERN NORWAY

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ABSTRACT: Rv80 is the main road to Bodoe, the largest city in Nordland County in Northern Norway. The road is one of only two roads to the Bodoe peninsula, and every day more than 3 000 cars travel on the road. About 30 minutes outside the city is Ytre Kistrand, an area with several slush flow paths known to close the road almost every year. Usually the slush flows, a mixture of snow and water, have been small and only causing trouble for traffic without being a great danger to vehicles. In February 2021 everything changed when a contractor on duty for the Norwegian Public Road Administration was killed when a slush flow hit his car and threw it upside down on the railway 10 meters below the road.

Two years later, in January 2023, an even bigger slush flow hit the road. The road was already closed by a smaller slush flow 100 meters away, and luckily the contractors managed to evacuate the vehicles in the runout zone in time before the road was hit.

Construction of protective measures will begin in the fall of 2023.

KEYWORDS: Slush flows, Highway, Protective measures.

1. INTRODUCTION

The city of Bodoe is situated on the Bodoe peninsula just north of the Arctic Circle in the northern part of Norway. The city has a population of about 42 000 and is the second-largest city in Northern Norway. There are only two roads to the city, where the highway RV80 is the most important with a traffic volume of almost 4 000 vehicles a day.

The highway runs through Ytre Kistrand, an area known for slush flows. Usually the slush flows, a mixture of snow and water, have been small and only causing trouble for traffic without being a great danger to vehicles. Since February 2021 two bigger slush flows have hit the road pushing the demand for protective measures.

Construction of protective measures will begin in the fall of 2023.

2. BACKGROUND

RV80 is a 60 kilometers long highway between the cities Bodoe and Fauske, connecting Bodoe to the European route E6, Norway's main north-south artery. About halfway between the cities RV80 runs through Ytre Kistrand, a rural area by the fjord Valnesfjorden consisting mainly of cabins.

The Norwegian Public Road Administration (NPRA) is responsible for the road, but snow clearence is outsourced to a private contractor.

2.1 Topography

Above the road are mountains peaking at around 1 000 meters, just below is the railway and the ocean.

The mountainside consists mainly of bare rock with a thin peat cover in places. The peat cover is more consistent below the tree line, which is at about 2-300 meters above mean sea level.

The terrain is mostly less than 30 degrees, but with slopes that are steeper. At about elevation 90 meters above mean sea level is an almost flat area.

2.2 Slush flows

Slush flows can be defined as rapid mass movement of water and snow and can release when the water content in the snowpack reaches a critical level due to higher water inflow than outflow.

Slush flows can release in gentle slopes with inclination between 5 and 25 degrees and obtain speeds over 25 m/s. Due to their fluid behavior they often don't stop until they reach a lake or the fjord.

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2.3 *Slush flow hazard at Ytre Kistrand*

The slush flow-prone stretch of the RV80 through Ytre Kistrand consists of 3 slush flow paths, and the road has been hit by several slush flows over the years. They are usually small with no reported accidents, but the road has been fully or partially closed several times. Usually, slush flows occur in all the 3 paths during an event, releasing one after another starting from the west. The path to the east release last and create the largest slush flows. The release area has been the almost flat area at about elevation 90 meters above mean sea level.

The slush flows release during periods with sudden temperature increases and heavy rain.

3. MAJOR EVENTS

3.1 *25 February 2021*

Early in the morning on 25 February 2021 two slush flows hit the road at Ytre Kistrand due to heavy rainfall and a sudden temperature increase after a long cold period. They were no bigger than trucks could drive through. The easternmost of the 3 slush flow paths had not released yet, but due to the historical sizes of the slush flows and the importance of keeping the road open to traffic, it was decided to clear the road. It was also decided that the contractor who was responsible for the snow clearence should follow the situation closely and wait for avalanche staff from the NPRA to arrive to discuss the hazard level. About 30 minutes later, and before the avalance staff arrived, a third slush flow released and hit a contractor and his car, throwing them on the railway below. The slush flow released in the easternmost path, and was the largest ever recorded in the area. The contractor was killed as he got stuck under his car in the debries.

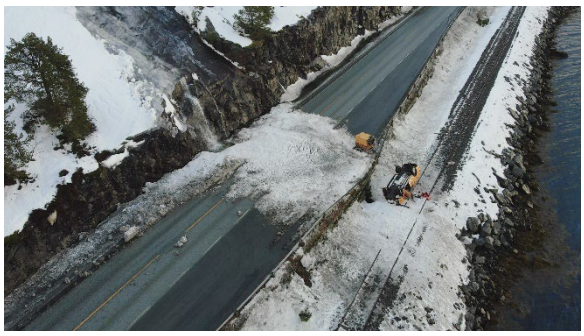

Figure 1:A contractor was killed when he got stuck under his car in the debries. Photo: Dag Theodor Andreassen

When the avalanche staff arrived, they did a hazard assessment by helicopter. Due to a lot of water accumulated in the snowpack and it was expected that the rain would continue, it was decided to keep the road closed until the next day.

The following day the rain had stopped, and the avalanche staff inspected the area using a drone. They discovered a second, large slush flow on the road in the easternmost path. It was also slush flows in new areas, both on the road and in the terrain. Some cabins were also damaged by slush flows.

3.2 *25 January 2023*

In the early morning on 25 January 2023, almost two years after the tragic accident, new slush flows hit the road. As the last time, the first released in the westernmost path and closed the road. Traffic was trapped in the slush flow-prone area, and a bus was standing in the easternmost path. The snow clearance contractor decided to evacuate the vehicles out of the area and managed to do so just in time for the third slush flow to hit the road.

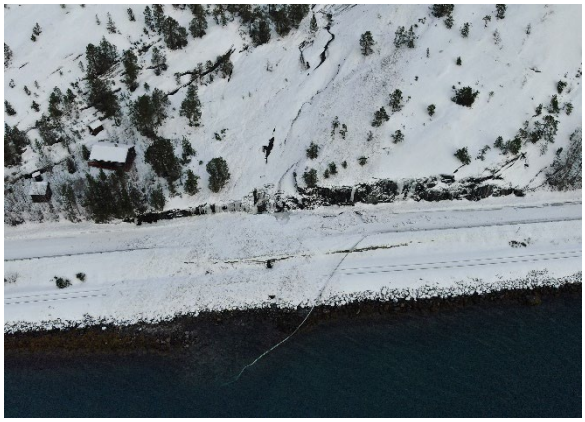

Figure 2: The slush flow in 2023 was even bigger than in 2021. Photo: Dag Theodor Andreassen

The slush flows were once again triggered by heavy rainfall and a sudden temperature increase after a long cold period, but was even bigger than those in 2021. The quick and determined reaction from the contractor probably prevented another accident by evacuating the vehicles.

3.3 *What has changed?*

The slush flows in 2021 and 2023 were bigger than earlier recorded events. If this is what we must expect in the future is uncertain, but what is the reason for these bigger events? One explanation is probably the elevation of the release area. Historically the slush flows supposedly have re-

lease 90 meters above mean sea level. Documentation from 2021 and 2023 indicates release height at least 2-300 meters above sea level.

4. PROTECTIVE MEASURES

The two major events in 2021 and 2023 have pushed the demand for protective measures at Ytre Kistrand. The bare rock slope above and railway and ocean below the road don't leave much room, but the measure consists of blasting into the mountain to create protective dams. The construction starts this fall.

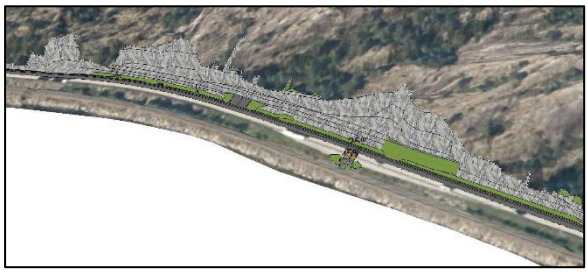

Figure 3:Protective measures will consist of dams blasted into the mountain. Screenshot of 3D-model created by Lars Joergen Sandvik.

5. CONCLUSION

The slush flow events in 2021 and 2023 indicates an increased risk for traffic. Prior to these events the slush flows have been too small to be a great danger to vehicles. The two major events have killed one person and almost resulted in another accident